Flocking, Herding and Schooling within Interconnected Intelligent Autonomous System

By Thomas Kidd - July-September 2017

The eventual introduction of interconnected intelligent autonomous systems, or interconnected yet independent systems run by artificial intelligence, will require us to think differently about system behavior in the future. For spectrum-dependent systems, this will be especially challenging since behavior in the electromagnetic environment isn't visible to the naked eye of an observer.

A flock of intelligent autonomous unmanned aircraft will resemble a starling murmuration, a few hundred seemingly leaderless birds moving as one, turning and twisting to avoid an adversary as they seek their target. Likewise, a school of underwater unmanned vehicles will resemble a pod of dolphins piloting the bow of an aircraft carrier through the sea.

And if we had the ability to see in the radio frequency spectrum, we would see a suite of radios changing color while sliding through the spectrum, their signals getting larger or smaller as power increases and decreases, or changing form altogether as they shape shift between waveforms. It is a shame we will never see radio and radar signals cooperatively sharing spectrum while avoiding a radio telescope and satellite uplink and downlink beams. It would be spectacular.

Understanding the behavior of intelligent autonomous systems is a challenge regardless of whether a system is made up of living and breathing animals or machines with artificial intelligence. For example, the behavior of a single bison is very different from that of a herd of bison.

Fish behave differently if they are schooling or shoaling. Schooling fish will not only swim closely together, they will form a very tight formation and will swim in a very synchronized manner. In contrast, schoaling fish stay together for social reasons, such as defense against predators, better feeding, and higher success in finding a mate.

In other words, shoals are simply aggregations of individuals; schools are shoals exhibiting polarized, synchronized motion. In shoals, no single individual controls the group and yet the group has its own behavior. Even when the behavior of an individual appears chaotic, the group appears to behave as a coordinated entity.

The same will be true of interconnected intelligent autonomous systems. No single controller device will have the ability to maintain situational awareness of every node in an infinitely complex continually morphing system. Devices will have certain behaviors controlling their own actions as individuals, and they will have other behaviors intended to enhance their abilities to cooperate in a group. Some of these behaviors may be by design; others will be learned over time. Some learning might only be shared among other members of the group; other knowledge may be shared widely among all who can use it.

We should also consider the reality that all interconnected intelligent autonomous system behavior won't be benign. A lumbering herd of wildebeests can quickly become a stampede. Individuals can perceive a situation that warrants caution, but a lone response can set off a chain reaction and panic can spread through the group; all of which may be artificially induced through some outside source. Herd, school or flock behavior, intended to protect members of the group, transforms and begins to operate at the expense of individuals. Predators may intentionally stampede their prey over a cliff just as an adversary may harm interconnected intelligent autonomous systems.

What does this mean as far as where the future takes us? We have lived alongside interconnected intelligent autonomous systems for millennia. Humans have learned to understand natural flocking, schooling, and herding behavior in animals of all species. We used this knowledge to become the dominant species on our planet. In the coming decades we will learn to understand this behavior among artificial systems as well. And nowhere is this behavior going to be stranger or more fascinating than in interconnected intelligent autonomous spectrum-dependent systems moving through the electromagnetic environment.

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